Morphological variability of *Pomatoschistus canestrinii* (Gobiidae), with the reduction of squamation and head canals

by

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ABSTRACT. - Specimens of *Pomatoschistus canestrinii* (Ninni, 1883) were collected from 2000 to 2002 along the eastern Adriatic coast. The morphology of 64 specimens from 11 locations was examined. High variabilities of important morphological characters, including body squamation, number of transverse rows of sensory papillae suborbital row *a*, and head canal development, were described. The present findings, contradictory to valid species diagnosis and genus diagnosis, extend species taxonomical delimitation. Additional data on ecology and geographical distribution of the eastern Adriatic specimens are provided.

RÉSUMÉ. - Variabilité morphologique chez *Pomatoschistus canestrinii* (Gobiidae) avec réduction de l'écaillure et des canaux céphaliques.

Les spécimens de *Pomatoschistus canestrinii* (Ninni, 1883) ont été collectés de 2000 à 2002 le long de la côte orientale de la mer Adriatique. La morphologie de 64 spécimens trouvés sur 11 localités a été examinée. Une grande variabilité des principaux caractères morphologiques a été observée dont l'écaillure du corps, le nombre de rangées transversales de la rangée suborbitale des papilles sensorielles *a*, ainsi que le développement des canaux céphaliques. Les présents résultats, contraires aux diagnoses de l'espèce et du genre, étendent la délimitation taxinomique de l'espèce. De nouvelles données sont fournies sur l'écologie et la distribution géographique des spécimens de la côte orientale de l'Adriatique.

Key words. - Gobiidae - *Pomatoschistus canestrinii* - MED - Adriatic Sea - Morphology - Squamation - Head canals.

Pomatoschistus canestrinii (Ninni, 1883) is an endemic gobiid from the Adriatic catchment (Gandolfi *et al*., 1982; Miller, 1986). The species inhabits brackish waters and freshwaters along the Adriatic coast, specific habitats which are vulnerable to the human threats. Samples of the *P. canestrinii* were collected by SCUBA diving and by electrofishing since 2000 on eleven locations along the eastern Adriatic coast (Fig. 1). Specimens showed high variability of important morphological characters, which disagrees with species diagnosis (head canals, rows of sensory papillae and squamation) in Miller (1986, 2004), and genus diagnosis (head canals) in Miller (1986). High intraspecific variability of these characters among Mediterranean and European gobies was known only for some *Knipowitschia* species (Ahnelt *et al*., 1995). Part of these morphological variabilities of *P. canestrinii* was already recorded as only character state by Gandolfi *et al*. (1982) (head canals reduction) and Sanzo (1911) (rows of sensory papillae). Therefore, the aim of the present work was to prove that all samples belong to *P. canestrinii*, to extend species taxonomical delimitation describing intraspecific variability of morphological characters, to provide modified species description useful for identification of all morphs of *P. canestrinii* and to discuss consequences of present finding on taxonomical position of *P. canestrinii*.

MATERIAL AND METHODS

Material examined

Eight females, 31.8+6.5 mm to 37.2+6.9 mm and 2 males, 33.7+7.3 mm and 34.0+7.4 mm, PMR (Prirodoslovni muzej Rijeka) VP852, Skradinski buk, the river Krka, Croatia, 27 Jun. 2000; 2 females, 23.5+4.3 and 23.7+4.5 mm, 1 male, 27.1+5.5 mm and 1 juvenile of unidentified sex, 15.0+2.9 mm, PMR VP853, the Baćinska lakes, Croatia, 26 Jun. 2000; 1 male, 26.1+5.7 mm, PMR VP854, the river Dobarnica, tributary of the river Zrmanja, Croatia, 2 Aug. 2000; 10 males, 31.5+6.8 mm to 41.6+8.1 mm, PMR VP999, Solin, the river Jadro, Croatia, 15 May 2001; 3 females, 27.9+5.7 to 33.7 + 6.9 and 6 males, 24.3+5.4 mm to 42.8+7.3 mm, PMR VP998, Omiš, the river Cetina, Croatia, 16 May 2001; 4 females, 35.7+7.7 mm to 37.2+7.2 mm, PMR VP999, Radmanove mlinice, the Cetina river, Croatia, 16 May 2001; 4 females, 30.6+6.6 mm to 38.8+7.0 mm and 2 males, 30.9+6.5 mm and 32.8+6.9 mm, PMR VP1000, the Žrnovnica river, Croatia, 18 May 2001; 3 females, 29.3+5.7 mm to 33.7+6.0 mm and 3 males, 23.8+4.6 mm to 31.9+5.9 mm, PMR VP1001, Omiš, the river Cetina, Croatia, 16 May 2001; 3 females, 26.8+5.5 mm to 28.2+6.2 mm and 3 males, 27.1+5.9 to 36.5+7.6 mm, PMR VP1112, Jankovića buk, the river Zrmanja, Croatia, 18 Oct. 2002; 1 female, 31.3+5.7 mm and 5 males, 24.8+5.3 mm to 40.9+8.4 mm, PMR VP1115, Žuvići, the river Krka, Croatia, 7 May 2003; 1 female, 27.2+5.9 mm and 1 male, 30.7+5.9 mm, PMR VP1244, Nadvoda, the river Zrmanja, Croatia, 17 Oct. 2002.

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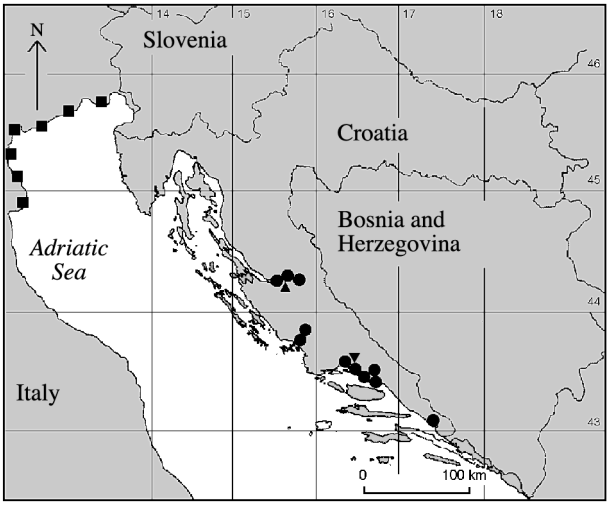

Figure 1. - Geographical distribution of *Pomatoschistus canestrinii* in the Adriatic Sea. Findings by (▼) Ninni, 1883, Kolombatović, 1891; (■) Gandolfi *et al*., 1982; (▲) Mrakovčić *et al*., 1994; (●) present research. *[Distribution géographique de* Pomatoschistus canestrinii *dans l'Adriatique.]*

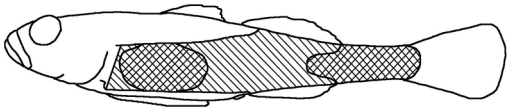

Figure 2. - *Pomatoschistus canestrinii*, schematic representation of the range of squamation. ///: female, 23.5 + 4.3 mm, PMR VP853; \\\: male, 34.1 + 7.9 mm, PMR VP999. *[*Pomatoschistus canestrinii*, représentation schématique de l'extension de l'écaillure. /// : femelle ; \\\ : mâle.]*

Methods

Meristic methods as in Miller (1988). Fin abbreviations: A, anal fin; C, caudal fin; D1, D2, first and second dorsal fins; P, pectoral fin; V, pelvic disc. The terminology of lateral-line system follows Sanzo (1911) and Miller (1986). The sex of the specimens was identified on size and shape of urogenital papilla. Lateral-line system and squamation of up to the 5 specimens from each location were examined by blanching in a mixture of 9 parts of 0.5% KOH solution and 1 part of 30% H_2O_2 for three hours and then staining in a solution containing 2% $KMnO_4$ and 0.3% H_2SO_4 for 20 s. This method results in specimens that are irreversibly changed and part of characters gets destroyed, so lateral line and squamation characters were checked on only about the half of the sample. The presence of pores was additionally checked by air injected at moderate pressure into the canals. Vertebral counts and dorsal pterygiophore sequences were examined on 14 cleared and stained specimens (PMR VP1001, PMR VP1115 and PMR VP1244) (Dingerkus and Uhler, 1977). The significance of the differences of meristic values among separate drainage basins was tested statistically using the non-parametric Kruskal-Wallis test. Mann-Whitney U-test was used for multiple comparisons.

RESULTS

Species identification

P. canestrinii differs from all other marine and freshwater Mediterranean gobiid species by the following combination of characters: (1) suborbital row *a* present, with one to several transverse rows, (2) suborbital series *c* with 5-6 transverse rows, (3) head canals present, with single interorbital canal and single pore λ, (3) branchiostegal membrane attached to entire side of isthmus, (4) predorsal area, back at least to the third articulated ray of D2, and breast scaleless, (5) row *cp* descending clearly below level of row *d*, (6) males with tiny intense black spots scattered on head and body and double dark spot on rear of D1 and (7) females with preorbital bar present, but lacking the chin blotch.

Morphology

Scales (n = 31) (Fig. 2). Body with ctenoid scales. Squamation variably developed, reduced to the separate axillar and posterior scaled areas (10 specimens) or connected along lateral midline (21 specimens). Head and anterior part of back naked. Back variably naked, scales beginning anteriorly from third articulated ray of D2 to rear end of D2. In specimens with discontinuous squamation, posterior scaled area of variable size, ending anteriorly from vertical of begin of D2 to vertical of rear end of D2. Scales at axilla not compactly placed, but scattered. Breast and abdomen naked, scales variably beginning from anteriorly at A, from begin to rear end of A. Caudal peduncle scaled. Scales in lateral series 28-39 (21 specimens with continuous squamation along lateral midline: 31: 2, 32: 2, 33: 5, 34: 2, 35: 4, 36: 4, 38: 1, 39: 1). Scales in transverse series 9-11 (12 specimens with squamation at beginning of A: 9: 4, 10: 7, 11: 1). Some samples included only specimens with continuous squamation (river Krka, river Jadro, river Žrnovnica), some only specimens with discontinuous squamation (Baćinska lakes) and some specimens with both types of squamation (river Zrmanja, river Cetina).

Head canals (n = 31) variously developed (Fig. 3). The posterior oculoscapular canal, carrying pores ρ^1 and ρ^2, present (5 specimens), present as open furrow (4 spms) or absent (22 spms). The preopercular canal present (18 spms), present as open furrow (9 spms) or absent (4 spms). The preopercular canal carrying pores γ and ε (14 spms), or carrying pores γ, δ and ε (4 spms). The anterior oculoscapular canal always present. The anterior oculoscapular canal normally developed carrying pores σ, λ, κ, α, ρ (25 spms), or with reduction of the snout part of anterior oculoscapular canal with pore σ, present just as open furrow from λ, or com-

pletely lost (6 spms). Two aberrations were noticed in a single specimen: second pore irregularly positioned near κ, and break of canal at pore α, with continuance of canal from additional pore near pore α. Specimens in some samples were all without the posterior oculoscapular canal (river Krka, Baćinska lakes), or samples included some specimens with and some without the posterior oculoscapular canal (the Zrmanja river, the Jadro river, the Žrnovnica river, the Cetina river). Specimens from the Baćinska lakes were all without the preopercular canal. All the other samples included specimens with and without the preopercular canal (river Zrmanja, river Krka, river Jadro, river Žrnovnica, river Cetina). The pore δ at preopercular canal was found in a part of specimens at river Jadro, river Žrnovnica, and river Cetina.

Rows and the number of sensory papillae (n = 31) as follows (Fig. 4):

(I) *Preorbital*. - Snout with three rows in median preorbital series: internal row *r (2-7)*, outer row *s (3-8)*, anterior row s^3 *(1-4)*. Lateral series *c* in four parts: superior (c^2) in the angle between anterior nostril and posterior nostril *(1-4)*; middle c^1 *(1-4)* close to anterior nostril; inferior upper c^2 *(2-5)* and lower c^1 *(2-5)* above lips.

(II) *Suborbital*. - Infraorbital row *a* extending forwards to anterior edge of pupil, consisting of 4-9 longitudinally arranged papillae. The transverse proliferation of row *a*, varying from single row *atp (3-11)*, to 5 transverse rows. Longitudinal row *b (7-17)* anteriorly beginning below rear edge of pupil (24 spms), or below rear border of eye (7 spms). Six to seven transverse row *c* below level of row *b*: *c1 (2-6)*, *c2* absent (19 spms) or present (*1-9*, 12 spms), *c3 (3-11)*, *c4 (4-11)*, *c5 (3-13)* and *cp (8-22)*. Transverse row *cp* ending below level of row *d*. Longitudinal row *d (14-28)* continuous, not reaching posteriorly row *cp*.

(III) *Preoperculo-mandibular*. - External row *e* and internal row *i* divided into anterior *(e: 14-24, i: 10-20)*, and posterior sections *(e: 16-33, i: 11-21)*; mental row *f (3-5)*.

(IV) *Oculoscapular*. - Anterior transverse series *tra* with upper section *(2-6)* above pore α, and lower section *(1-5)* behind pore α, anterior longitudinal row x^1 divided by posterior transverse row, *trp (2-11)* in anterior section *(4-13)* above row *z* and posterior section *(2-6)* above row *q*, posterior longitudinal row x^2 *(2-7)* over row *y (1)*; row *z (4-12)*, row *q (1-2)* behind transverse row *trp* and below posterior section of x^1. Axillary rows as^1 *(4-13)*, as^2 *(3-11)*, as^3 *(3-16)*, la^1 *(2-4)* and la^2 *(1-5)*.

(V) *Opercular*. - Transverse row *ot (12-30)*; superior longitudinal row *os (8-20)*; and inferior longitudinal row *oi (4-11)*.

(VI) *Anterior dorsal*. - Row *n (3-7)*, row *g (2-8)*, row *m* absent (10 spms) or present (*1-4*, 21 spms) and row *h (5-13)*, row *o* absent (the first anterior papilla of row *g* sometimes distant from the rest of row *g*, could represents row *o*).

Specimens highly differed in number of sensory papillae in rows. The total

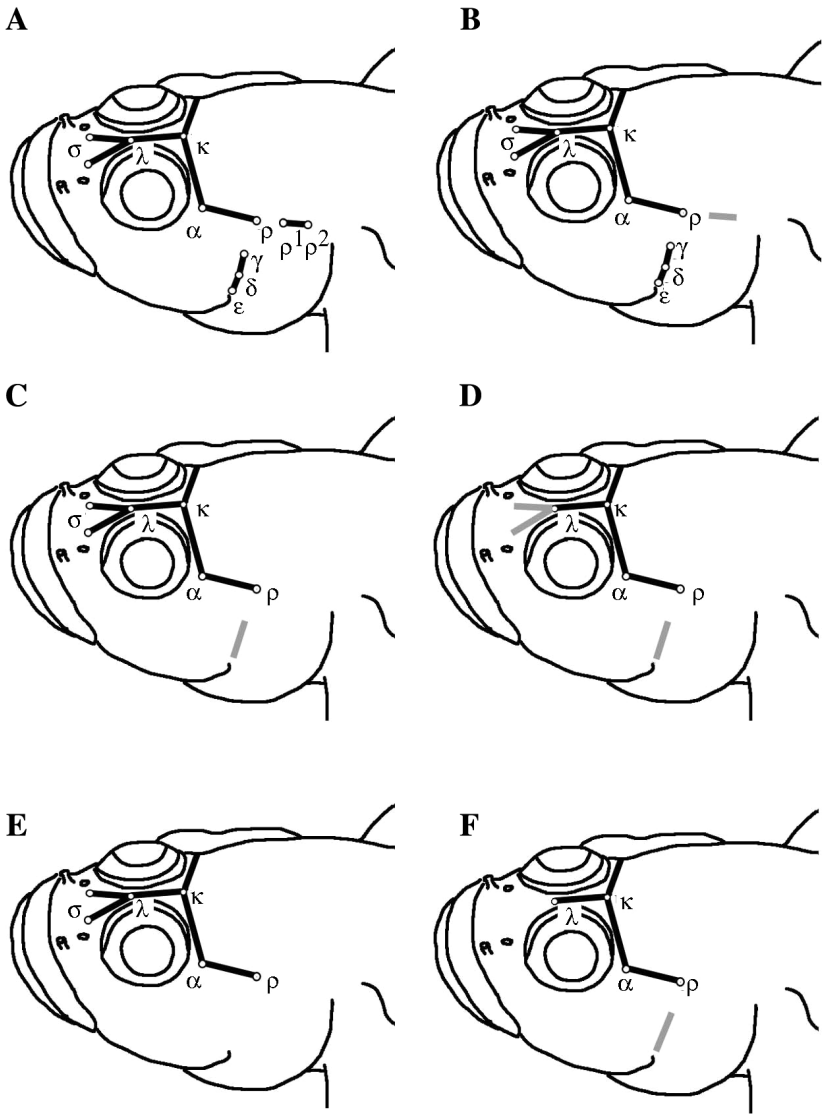

Figure 3. - *Pomatoschistus canestrinii*. Schematic representation of variously developed head canals. **A-D**: PMR VP997; **E**: PMR VP1115; **F**: PMR VP853. ○: pores; black lines: canals; grey lines: furrows. See terminology in text. *[*Pomatoschistus canestrinii. *Représentation schématique de l'état de développement des canaux céphaliques.]*

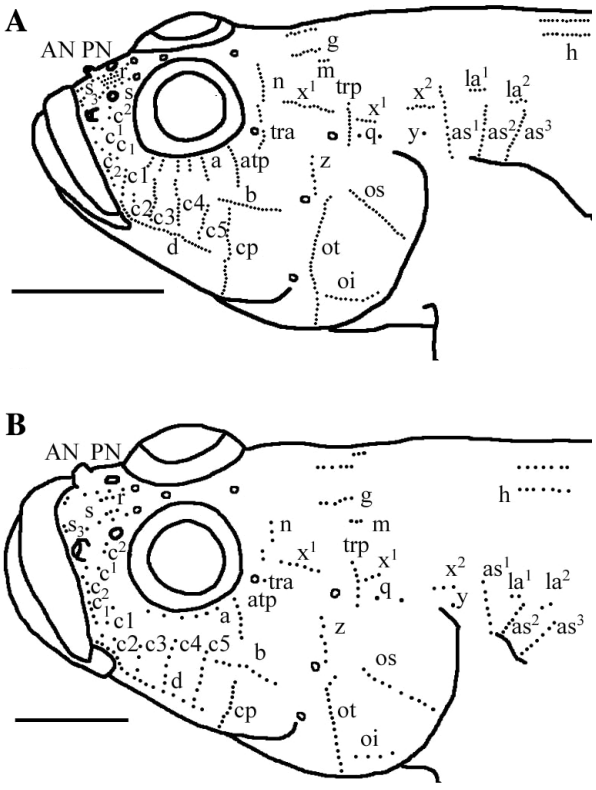

Figure 4. - *Pomatoschistus canestrinii*. **A**: Head lateral-line sensory papillae with high papillae count, female, 36.2 + 7.3 mm, PMR VP852; **B**: Head lateral-line sensory papillae with low papillae count, male, 32.8 + 6.9 mm, PMR VP1000. AN, PN, anterior and posterior nostrils; see other terminology in text. Scale = 2 mm. *[*Pomatoschistus canestrinii, ***A** *: Papilles sensorielles de la ligne latérale de la tête avec un nombre élevé de papilles, femelle ;* ***B** *: Papilles sensorielles de la ligne latérale de la tête avec un petit nombre de papilles, mâle.]*

number of all sensory papillae in head area varied in specimens from 209 to 450 papillae: the river Zrmanja 281-322, the river Krka 318-450, the river Jadro 276-325, the river Žrnovnica 259-366, the river Cetina 209-357, and the Baćina lakes 262-268. The number of sensory papillae among separate drainage basins were significantly different (H Kruskal-Wallis = 15.2, $p < 0.05$) (Tab. I). All specimens from river Žrnovnica had just a single transverse proliferation of row *a*, row *atp*; two specimens from Baćinska lakes had both 2 transverse rows of row *a*; number of transverse rows of row *a* varied in specimens from river Zrmanja (1-3 rows), river Krka (2-5 rows), river Jadro (1-3 rows) and river Cetina (1-4 rows). Either specimens in some samples were all without the row *c2* (the river Jadro, the Baćina lakes), or samples included specimens with and without the row *c2* (the river Zrmanja, the river Krka, the river Žrnovnica, the river Cetina). Specimens from the river Krka and the Baćina lakes all had the row *m*. All the other samples had specimens with and without the row *m* (the river Zrmanja, the river Jadro, the river Žrnovnica, the river Cetina).

Fins (n = 64). D1 V-VI (V: 2, VI: 62); D2 I/7-I/9 (7: 1, 8: 46, 9: 17); A I/7-I/9 (7: 5, 8: 51, 9: 8); C 11-13 branched rays (10: 8; 11: 53, 12: 2), 14-15 articulated rays (14:8, 15:55) and the specimen 48.2 mm, PMR VP999, with damaged C; P 15-17 (both sides: 15: 20, 16: 68, 17: 40). V disc complete, rear edge of anterior membrane smooth (21) to more or less crenate (43). P uppermost rays not free from membrane. C rounded. Significant differences among separate drainage basins, but geographically erratic, were found only for P rays count with median value at 15 (river Jadro), 16 (river Krka, river Žrnovnica, river Cetina) and 17 (river Zrmanja, Baćinska lakes) (H Kruskal-Wallis = 49.5, $p < 0.05$) (Tab. I).

Vertebrae and dorsal pterygiophores (n = 14). Number of vertebrae mode: 12+18, 12 + 19 (11 + 18: 1; 11 + 19: 1; 12 + 18:7, 12 + 19:5), including urostyle. Dorsal pterygiophore formula mode: 3-122100 and 3-122010 (3-121100: 1; 3-122100: 9, 3-122010: 3; 3-121200: 1). The number of vertebrae among separate drainage basins were significantly different (H Kruskal-Wallis = 6.01, $p < 0.05$) (Tab. I).

Coloration (n = 64) (Fig. 5). Preserved specimens show several different patterns of skin pigmentation based on size, sex and season of collecting: females, adult males during breeding season, adult males out of breeding season, immature males and juveniles. However, no important difference was noticed among specimens of similar size, collecting season and the same sex from different samples. Females body pale yellowish-brown, with 3 to 7 dark blotches along lateral midline of variable size and intensity. In some females distinguishable ill defined tiny brownish spots scattered along lateral side of body. Upper part stippled, with five to six pale saddles. Underside, including breast and belly, whitish. Head with stippled upper part and scattered poorly defined tiny

Table I. - Results of Mann-Whitney U-test for multiple comparisons of P rays count (1st column), the total number of all sensory papillae in head area (2nd column) and the number of vertebrae (3rd column). NW: northwest; SE: southeast; *: significant difference ($p < 0.05$) between two groups of samples; ns: not significant. *[Résultat du test-U de Mann-Whitney pour des comparaisons multiples du nombre de rayons aux pectorales (1e colonne), du nombre total de toutes les papilles sensorielles de la tête (2e colonne) et du nombre de vertèbres (3e colonne). NW : nord-ouest ; SE : sud-est ; * : différence significative ($p < 0,05$) entre deux groupes ; ns : non significatif.]*

NW → SE	Zrmanja			Krka			Jadro			Žrnovnica			Cetina			Baćina		
Zrmanja				*	*	ns	*	ns		*	ns		*	ns	ns	ns	ns	
Krka							*	*		*	ns		ns	*	*	ns	*	
Jadro										ns	ns		*	ns		*	ns	
Žrnovnica													*	ns		*	ns	
Cetina																ns	ns	
SE Baćina																		

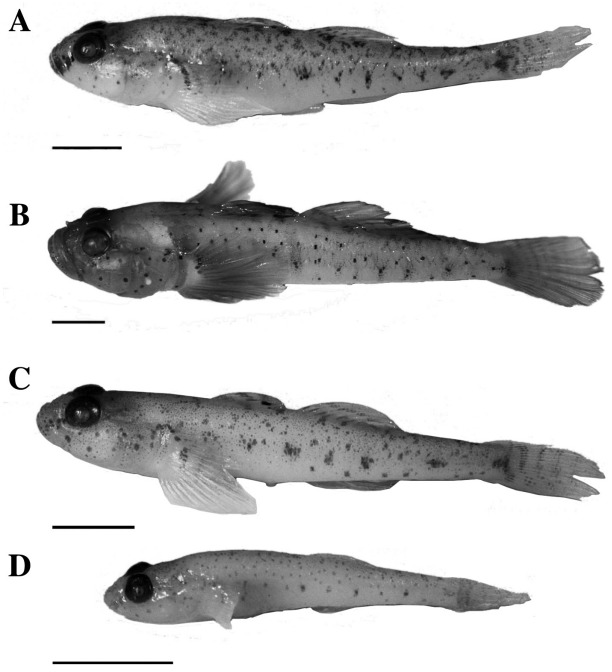

Figure 5. - *Pomatoschistus canestrinii*, patterns of skin pigmentation. **A**: Female, 31.8 + 6.5 mm, PMR VP852; **B**: Adult male during breeding season, 40.8 + 8.2 mm, PMR VP999; **C**: Immature male, 28.5 + 5.5 mm, PMR VP998; **D**: Juvenile, 15.0 + 2.9 mm, PMR VP853. Scale bars = 5 mm. *[*Pomatoschistus canestrinii*, patrons de pigmentation de la peau. **A** : Femelle ; **B** : Mâle adulte pendant la saison de reproduction ; **C** : Mâle immature ; **D** : Juvénile.]*

brownish spots on lateral side. Darkish preorbital bar present, but lacking the blotch on the chin. Whitish mark above operculum. D1 with 3 pigmented longitudinal bands, brownish spot distinguishable from middle band visible in some females between D1 V and VI ; D2 with 3 to 4 pigmented longitudinal bands; C with 3-5 vertical moonlike bands, P with pale area in the origin of upper rays, behind it vertically elongated brownish mark; A and V colourless. Some females, including a few ripening specimens, show more intensive D1 spot and intensive tiny dark spots all over their body and head similar to non-breeding males. Body of adult males during breeding season dusky to brownish, with 3 to 6 dark blotches along lateral midline, sometimes almost invisible. Intensive tiny black spots scattered along lateral side of body, grouped over lateral dark blotches. Upper part of body stippled. Underside, including belly, yellowish-brown. Head, including underside, and breast brown, with scattered intensive tiny black spots on lateral side of head. V shape or triangular shape white mark on nape. D1 with 3 pigmented longitudinal bands, black spot distinguishable between D1 V and VI, second, smaller black spot behind D1 VI; D2 with 3 to 5 pigmented longitudinal bands; C with 6-7 vertical moonlike pigmented bands; A brown, with intensive deeper dark fin edge; P brown, with vertical white band in the origin of upper rays, behind it vertically arranged intensive tiny black spots; V dark brown. Adult males out of breeding season and immature males differ from breeding males in having no intensive brown or dark coloration of head, body and fins. Body pale yellowish-brown, with 4 to 5 dark blotches along lateral midline of variable size and intensity. Intensive tiny black spots scattered along lateral side of body, grouped over lateral dark blotches. Upper part stippled, underside whitish. Head with dusky upper part and scattered intensive tiny black spots on lateral side. Preorbital bar visible. Whitish mark above operculum. D1 with 3 pigmented longitudinal bands, black spot distinguishable between D1 V and VI, second, smaller black spot behind D1 VI; D2 with 3 to 4 pigmented longitudinal bands; C with 3-6 vertical moonlike pigmented bands; P with pale area in the origin of upper rays, behind it vertically elongated brownish mark; A and V colourless. Body of juvenile (SL = 15.0 mm) with scattered melanophores on upper part. Larger spots along lateral midline. Underside only with melanophores along A base. Head with rarely scattered melanophores, preorbital bar visible, nape more intensively pigmented. D1, D2 and origin of C rarely pigmented. P with vertical mark in the origin of upper rays, A and V colourless.

Ecology

The specimens were found at depths from 0.2 to 6 m. Collecting sites were mostly in the sea-influenced parts of rivers and lakes (Jankovića buk, the river Zrmanja; the river Krka; the river Jadro; the river Žrnovnica; the river Cetina; the Baćina lakes), but also in fresh water parts of rivers separated from the sea by cascades (the river Dobarnica; Nadvoda, the river Zrmanja). The bottom surfaces were usually bare or poorly covered with vegetation. The bottom structure varied from clear coarse sand (Omiš, the river Cetina), gravel and cobbles (the river Žrnovnica), coarse sands between large rocks (Jankovića buk, the river Zrmanja; Skradinski buk, the river Krka), boulders, cobbles and gravel (Radmanove mlinice, the river Cetina). Such variable bottom structure are, in some locations, more or less, muddy (Žuvići, the river Krka; the river Jadro; the Baćina lakes).

Geographical distribution

The localities listed in the Material are situated in Dalmatia, Croatia: the river Zrmanja and its tributary Dobarnica, the river Krka, the river Jadro, the river Žrnovnica, the river Cetina, and the Baćina lakes (Fig. 1).

DISCUSSION

All specimens were assigned to the same taxa and identified as *P. canestrinii* based on morphological evidence (see species identification). The variability of characters (scales, head canals, rows and the number of sensory papillae, fins) within the each sample and overlapping of the character

states between samples prevent recognition of separate taxa among separate species populations. Significant differences among separate river basins were found for P rays count, the total number of all sensory papillae in head area and the number of vertebrae. However, geographical pattern of significant differences was dissimilar among these three characters (Tab. I). Therefore, they were useless in recognising morphologically separate species populations. No differences in pattern of coloration were present among samples for specimens of similar maturity, sex and season of collecting. In some other freshwater gobiids (like species of genus *Knipowitschia*) geographically erratic variability of characters is genuine characteristic of the species (Ahnelt *et al*., 1995; Kovačić and Pallaoro, 2003).

The findings of Gandolfi *et al*. (1982) on head canals reduction were lately recognised (Miller, 2004). Nevertheless, I agree with Gandolfi *et al*. (1982) that the description of doubled interorbital head canals reunited at single pore κ published by Cavinato (1952) is an error. Miller (1986) described suborbital row *a* with two transverse rows as key character of *P. canestrinii*. However, the illustration of lateral line system with four transverse rows of row *a* was published by Sanzo (1911) and with three transverse rows by Ninni (1938). There was no previously published data on reduction of squamation and on variability of presence of row *m* for *P. canestrinii*.

The taxonomic position of *P. canestrinii* within genus *Pomatoschistus* was already reconsidered by De Buen (1930), who established subgenus *Ninnia* for this species and Whitley (1951), who replaced *Ninnia* with a monotypic genus *Ninnigobius*, for the reason of priority. However, these splittings of genus *Pomatoschistus* were proposed without present knowledge on variability of head canals and squamation of *P. canestrinii*, and they were not accepted by later authors (Miller, 1973, 1986, 2004). The presently found variable development of head canals and variably scaled body in *P. canestrinii* do not comply with the valid short description (Miller, 1986), differential diagnosis (Miller, 1981; Miller and McKay, 1997) or key characters (Miller, 1986, 2003) of genus *Pomatoschistus*. *P. canestrinii* differs morphologically from all other *Pomatoschistus* species in: (1) the loss of the posterior oculoscapular canal, preopercular canal and the snout part of anterior oculoscapular canal, at least in a part of population; (2) reduction of squamation to the separate axillar and posterior scaled areas, at least in a part of population; (3) and row *m* of variable presence. Furthermore, *P. canestrinii* is the only *Pomatoschistus* occurring both in brackish waters and in freshwaters. All other *Pomatoschistus* species live in marine habitats or marine to brackish habitats. The present finding demands extended taxonomical delimitation of genus *Pomatoschistus* to cover *P. canestrinii*, or description of new, monotypic genus for this species. Is *P. canestrinii* an ex-group descended from *Pomatoschistus* with autapomorphic reduction of head canals and reduction of squamation as specialisation in brackish and freshwater conditions, parallel to *Hyrcanogobius*, *Knipowitschia* and *Economidichthys*? Or is *P. canestrinii* the sister group to *Hyrcanogobius, Knipowitschia* and *Economidichthys*, with at least part of these reductions early emerged and shared as synapomorphies among these four taxa? It is hard to make any choice based on known morphological evidence. Regarding osteology, *P. canestrinii* share the mode of dorsal pterygiophores with some *Knipowitschia* and *Economidichthys* species, as well as with some *Pomatoschistus* species (Miller and McKay, 1997). The mode of vertebral count resembles more those of *Knipowitschia* and *Economidichthys* species, that of *Pomatoschistus* species (Miller and McKay, 1997). The analyses of isozyme genetics show closer relationship of *P. canestrinii* to *Pomatoschistus* species than to *Knipowitschia* species (Miller *et al*., 1994; Miller and McKay, 1997). Additional research, with material based on Italian populations and possible samples from other countries (Slovenia, L. Lipej, pers. comm., Nov. 2003; Monte Negro, R. Šanda, pers. comm., May 2004), would help with the decision on re-establishing a new monotypic genus based on *P. canestrinii*.

The present work indicates the widespread distribution of eastern Adriatic population of *P. canestrinii*. However, this distribution does not diminish the risk of loss of this population, in view of the fact that almost all collecting locations are heavily threatened by present and planned human activities: the river Zrmanja is exposed to frequent accidents by toxic pollutions from non-remediated sites of the previous aluminium production industry and to present and planned engineering for water supplies; the city of Knin discharges non-treated wastewater effluents with plant nutrients and industrial wastes in the river Krka, which caused intensive eutrophication; the river Jadro, probably one of the most polluted rivers in the Adriatic catchment, is heavily influenced by nearby cement kiln industry and chemicals processing industry; urbanisation during the last decades has turned the area around the river Žrnovnica in the eastern suburb of the city of Split, the largest and the fastest growing urbanised area on the eastern Adriatic coast; the river Cetina is heavily influenced by engineering for hydropower, with severe effects on downstream habitats; the intensified agriculture in catchment of Baćina lakes loads this lakes with plant nutrients and pesticides. These habitats have already been changed and the conservation programme and management are needed to ensure the survival of *P. canestrinii* population.

Acknowledgements. - I thank P.J. Miller for suggestions and criticism of this paper. Field assistance in collecting samples was provided by D. Radović and A. Pallaoro.

REFERENCES

AHNELT H., BIANCO P.G. & H. SCHWAMMER, 1995. - Systematics and zoogeography of *Knipowitschia caucasica* (Teleostei: Gobiidae) based on new records from the Aegean Anatolian area. *Ichthyol. Explor. Freshw.*, 6: 49-60.

CAVINATO G., 1952. - Revisione del *Gobius* della Laguna Veneta. *Arch. Oceanogr. Limnol.*, 7: 1-56.

DE BUEN F., 1930. - Sur une collection de Gobiinae provenant du Maroc. Essai de synopsis des espèces de l'Europe. *Bull. Soc. Sci. Nat. Phys. Maroc*, 10: 120-147.

DINGERKUS G. & L.D. UHLER, 1977. - Enzyme clearing of alcian blue stained small vertebrates for demonstration of cartilage. *Stain Technol.*, 52: 229-232.

GANDOLFI G., TORRICELLI P. & A. CAU, 1982. - Osservazioni sulla biologia del ghiozzetto cenerino, *Pomatoschistus canestrinii* (Ninni) (Osteichthyes, Gobiidae). *Nova Thalassia*, 5: 97-123.

KOLOMBATOVIĆ G., 1891. - Gobies of the marine Area of Split, Dalmatia. 29 p. Split, Croatia: C. K. Velika realka u Splitu. [in Croatian and Italian]

KOVAČIĆ M. & A. PALLAORO, 2003. - Is *Knipowitschia caucasica-like* form from the Adriatic Sea a new Goby species? Evidence from a morphological approach in the eastern Adriatic Sea. *Cybium*, 27(2): 81-164.

MILLER P.J., 1973. - Gobiidae. *In*: Check-List of the Fishes of the North-Eastern Atlantic and of the Mediterranean (CLOFNAM) (Hureau J.-C. & T. Monod, eds), pp. 483-515. Paris: UNESCO.

MILLER P.J., 1981. - A new *Pomatoschistus* from Mediterranean, and redescription of *P. tortonesei* Miller, 1968. *Senckenb. Biol.*, 62: 5-19.

MILLER P.J., 1986. - Gobiidae. *In*: Fishes of the North-eastern Atlantic and the Mediterranean, Vol. III (Whitehead P.J.P., Bauchot M.-L., Hureau J.-C., Nielsen J. & E. Tortonese, eds), pp. 1019-1085. Paris: UNESCO.

MILLER P.J., 1988. - New species of *Corcyrogobius, Thorogobius* and *Wheelerigobius* from West Africa (Teleostei: Gobiidae). *J. Nat. Hist.*, 22: 1245-1262.

MILLER P.J., 1990. - The endurance of endemism: The Mediterranean freshwater gobies and their prospects for survival. *J. Fish Biol.*, 37(Suppl. A): 145-146.

MILLER P.J., 2003. - Family Gobiidae Risso, 1826. *In*: The Freshwater Fishes of Europe, Vol. 8/I (Miller P.J., ed), pp. 157-162. Wiebelsheim: Aula Verlag.

MILLER P.J., 2004. - *Pomatoschistus canestrinii* (Ninni, 1883). *In*: The Freshwater Fishes of Europe, Vol. 8/II (Miller P.J., ed), pp. 284-292. Wiebelsheim: Aula Verlag.

MILLER P.J. & S.I. MCKAY, 1997. - The affinities of European sand gobies (Teleostei: Gobiidae). *J. Nat. Hist.*, 31: 1457-1482.

MILLER P.J., SERVENTI M., SOREGAROLI D., TORRICELLI P. & G. GANDOLFI, 1994. - Isozyme genetics and the phylogeny of Italian freshwater gobies (Teleostei: Gobioidei). *J. Fish Biol.*, 44: 439-451.

MRAKOVČIĆ M., SCHNEIDER D. & M. KEROVEC, 1994. - Freshwater gobies of Croatia. *Period. Biol.*, 96: 441-443.

NINNI A.P., 1883. - Nuova specie di *Gobius*. *Atti Soc. Venet. Trent. Sci. Nat. Pad.*, 8: 276-279.

NINNI E., 1938. - I *Gobius* dei mai e elle acque interne d'Italia. *Mem. Comm. Talassogr. Ital.*, 242: 1-169.

SANZO L., 1911. - Distribuzione delle papille cutanee (organi ciatiforme) e suo valore sistematico nei Gobi. *Mitt. Zool. Stat. Neapel*, 20: 249-328.

WHITLEY G.P., 1951. - New fish names and records. *Proc. Roy. Zool. Soc. NSW*, 1949-1950: 61-68.

Reçu le 23 juillet 2004.
Accepté pour publication le 14 février 2005.